

MONOJET RATES IN ULTRARELATIVISTIC HEAVY ION COLLISIONS

I.P.Lokhtin, L.I.Sarycheva, A.M.Snigirev

119899, Moscow State University, Nuclear Physics Institute, Moscow, Russia

Abstract

Basing on model concepts we research the monojet-to-dijet ratio as a function of the jet energy detection threshold in ultrarelativistic collisions of nuclei. We provide an comparative analysis of the contribution to monojet yield from gluon radiation before initial hard parton-parton scattering and from non-symmetric dijet energy losses in quark-gluon plasma, which expected to be created in ultrarelativistic heavy ion collisions.

Talk given at XIVth Conference on Ultrarelativistic Nucleus-Nucleus Collisions
"Quark Matter'99", Torino, Italy, May 10-15, 1999

Hard jet production is considered to be an effective probe for formation of super-dense matter – quark- gluon plasma (QGP) in future heavy ion collider experiments at RHIC and LHC. High p_T parton pair (dijet) from a single hard scattering is produced at the initial stage of the collision process (typically, at $\lesssim 0.01$ fm/c). It then propagates through the QGP formed due to mini-jet production at larger time scales (~ 0.1 fm/c), and interacts strongly with the comoving constituents in the medium. The various aspects of hard parton passage through the dense matter are discussed intensively [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. In particular, the strong acoplanarity of dijet transverse momentum [1, 2, 3], the dijet quenching (a suppression of high p_T jet pairs) [5] and a monojet-to-dijet ratio enhancement [8] were originally proposed as possible signals of dense matter formation in ultrarelativistic ion collisions.

In the simple QCD picture for a single hard parton-parton scattering without initial state gluon radiation (i.e. when jets from dijet pair escape from primary hard scattering vertex back-to-back in azimuthal plane with equal absolute transverse momentum values, $p_{T1} = p_{T2}$) a monojet is created only if one of the two hard partonic jets loses so much energy due to multiple scattering in the dense matter that effectively we can detect only one single jet in the final state. The monojet rate is obtained by integrating the dijet rate over the transverse momentum p_{T2} of the second (unobserved) jet with the condition that p_{T2} be smaller than the threshold value p_{cut} (or the threshold jet energy $E_T = p_{cut}$ ¹). Then rate of dijets R^{dijet} with $p_{T1}, p_{T2} > p_{cut}$ and monojets R^{mono} with $p_{T1} > p_{cut}$ ($p_{T2} < p_{cut}$) in central AA collisions is calculated as integral over all possible jet transverse momenta p_{T1} , p_{T2} and longitudinal rapidities y_1 , y_2 .

At first in the framework of the simple model [14] we demonstrate that monojet-to-dijet ratio can be related to mean the acoplanarity measured in the units of the jet threshold energy, namely

$$\frac{R^{mono}}{R^{dijet}} \propto \frac{\langle |K_T| \rangle}{E_T}. \quad (1)$$

The results of physics simulation have been obtained in the three scenarios for jet

¹Due to fluctuations of the transverse energy flux arising from a huge multiplicity of secondary particles in the event, the "true" jet recognition in ultrarelativistic heavy ion collisions is possible beginning only from some energy threshold [13].

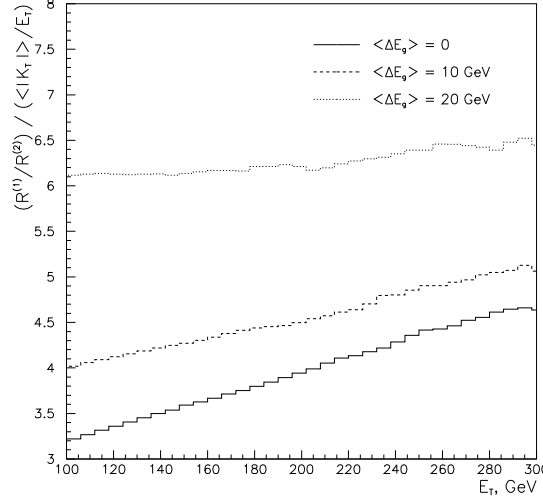


Figure 1: (Monojet/dijet)/(<mean acoplanarity/ E_T) as function of jet energy threshold E_T .

quenching due to collisional energy losses ² of jet partons in mid-rapidity region $y = 0$ [11, 14]: (i) no jet quenching, (ii) jet quenching in a perfect longitudinally expanding QGP (the average collisional energy losses of a hard gluon $\langle \Delta E_g \rangle \simeq 10$ GeV, $\langle \Delta E_q \rangle = 4/9 \cdot \langle \Delta E_g \rangle$), (iii) jet quenching in a maximally viscous quark-gluon fluid, resulting in $\langle \Delta E_g \rangle \simeq 20$ GeV. Initial state gluon radiation has been taken into account with the PYTHIA Monte-Carlo model [15] at c.m.s. energy $\sqrt{s} = 5.5A$ TeV.

Then we conclude that rescattering of hard partons in medium results in weaker E_T -dependence of ratio R^{mono}/R^{dijet} to $\langle |K_T| \rangle / E_T$ (see fig.1). With growth of energy losses the ratio we are interested in has a tendency to be constant, what would be interpreted as the signal of super-dense matter formation.

²Although the radiative energy losses of a high energy parton dominate over the collisional losses by up to an order of magnitude, it will, in the first place, soften particle energy distributions inside the jet, increase the multiplicity of secondary particles, but will not affect the total jet energy [12]. On the other hand, the collisional energy loss turns out to be practically independent on jet cone size and emerges outside the narrow jet cone.

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